XX. *Flame Spectra at High Temperatures.*—Part II. *The Spectrum of Metallic Manganese, of Alloys of Manganese, and of Compounds containing that Element.*

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[Plate 14.]

The Spectrum of Metallic Manganese.

The spectrum of manganese obtained in various ways has been the subject of much investigation. Huggins, Thalén, and Lecocq de Boisbaudran have studied the spark spectra of manganese compounds; Ångström, Thalén, Cornu, Lockyer, also Liveing and Dewar, the arc spectrum; Simmler, von Lichtenfels, Lecocq de Boisbaudran and Lockyer have investigated the flame spectra, while Marshall Watts has given us most accurate measurements of the wave-lengths of lines and bands observed in the spark and oxyhydrogen flame spectra of spiegel-eisen, manganese dioxide, and other compounds of this metal.

An account of the spectrum of manganese obtained by the oxyhydrogen flame was prepared for insertion in Part I. of this research, but it was omitted for the reason that when investigating the spectrum of the Bessemer flame, I found it necessary to compare the spectrum of elementary manganese under different conditions with that of its oxide. Comparative experiments were made with various alloys containing manganese, and with compounds of that substance ignited in the oxyhydrogen flame.

The results showed that the alloys invariably gave a more distinct and extensive series of bands than the compounds containing the same proportion of manganese as the alloys. Moreover, the bands were always accompanied by lines, and the lines were stronger in the spectra of the alloys than in the compounds. The principal lines were always distinctly visible when the conditions were such that the bands could barely be seen. For instance, when the spectrum of spiegel-eisen was photographed with a very short exposure, in fact by a mere flash of light, or when steel containing a very small amount of manganese was burnt in the oxyhydrogen flame and its spectrum photographed. The various materials used have been ferro-manganese, containing 80 per cent. of manganese, spiegel-eisen, containing 18 to 20 per cent., silico-spiegel, containing 10 per cent. of silicon and 18 to 20 per cent. of manganese, pig-iron, composition undetermined, and Turton's tool steel.

Ferro-manganese yielded a very fine spectrum after an exposure varying from 15 to 30 minutes, better in fact than any compound of that substance. It may thus be generally stated that manganese alloys containing iron yield a more distinctive spectrum of manganese than any compound containing the same proportion of that element. (See the upper spectra on Plate 14.)

Metallic manganese, deposited on platinum by the electrolysis of a perfectly pure solution of the chloride, was heated in the oxyhydrogen flame for half-an-hour and its spectrum photographed.

Pure manganic oxide was prepared from a solution of potassium permanganate by the action of alcohol and a small quantity of sulphurous acid. The precipitated oxide, washed and ignited, was heated on a support of kyanite in the flame of the oxyhydrogen blow-pipe for an hour and 20 minutes. It will be seen that as there is a considerable difference between 30 and 80 minutes in the exposure, a corresponding difference in the width and intensity of the bands common to the two spectra obtained from the metal and the oxide may be anticipated. Also bands invisible or barely discernible in the spectrum of the metal with 30 minutes' exposure will, it is possible, be clearly defined after an exposure of the oxide for 80 minutes. The same spectrum as regards its leading features as that yielded by metallic manganese, was obtained by deflagrating a mixture of finely-powdered potassium permanganate and lamp-black.

Manganese.

Metallic manganese, deposited on platinum by the electrolysis of a perfectly pure solution of the chloride, was heated in the oxy-hydrogen flame for half an hour. References: F. and T., Fievez and Thalén; V. and T., Vogel and Thalén; L. de B., Lecocq de Boisbaudran; K. and R., Kayser and Runge; C., Cornu.

Description of Spectrum.	$\frac{1}{\lambda}$.	λ.	References.
More refrangible edge of band, weak . . .	17078	5855	5855·2, Fe, F. and T.
Line, doubtful	17202	5813	
„ „	17242	5800	5800, Fe, F. and T., also L. de B.
More refrangible edge of very weak band, or a line.	17350	5764	
More refrangible edge of very weak band, or a line.	17451	5730	Uncertain.
More refrangible edge of very weak band, or a line.	17508	5712	Uncertain.
Edge of band, or a line	17568	5692	
„ „ and apparently a line . . .	17786	5622	5623·5, Fe, F. and T.
Strongest part of band	17863	5598	
Edge of band hazy	17886	5591	5591, Fe, F. and T.

Manganese—(continued).

Description of Spectrum.	$\frac{1}{\lambda}$.	λ.	References.
Line, or less refrangible edge of band	17950	5571	5571·3, Fe, F. and T.
,, more ,, ,, ,,	18000	5556	
Line	18077	5532	
,,	18180	5500	
,,	18255	5478	5478, Fe, F. and T.
,, or edge of band	18298	5465	
,, distinct, rather broad	18365	5445	5446, Fe, F. and T.
,, sharper and weaker	18390	5438	
More refrangible edge of strong band	18510	5402	
Band	18548	5391	5392·3, Fe, F. and T.
Edge strong	18620	5370·5	5370·6, Fe, F. and T.
Fine line	18642	5364	
Edge of band doubtful	18703	5347	5316, Fe, F. and T.
,, ,, ,,	18815	5315	
More refrangible edge of band coincident with solar line E.	18973	5270	5269·5, Fe, F. and T. 5270·3, K. and R.
More refrangible edge of band	19100	5235	5232·1, Fe, F. and T.
,, ,, ,, ,,	19235	5199	5198·2, Fe, F. and T.
,, ,, ,, ,,	..	5166	5167, Fe, F. and T.
Line	20702	4830	4831·8, Fe, F. and T.
,,	20870	4791·5	
,,	20998	4762	4761·3, Mn, Thalén, Angström.
,,	24605	4064	4052·9, Mn, Ångström. 4063, Fe, V. and T.
,,	24656	4056	
,,	24694	4049·5	4048, Mn, Ångström. 4048·7, Mn, Cornu.
,,	24742	4041·3	4040·6, Mn, Ångström.
Strongest group of lines in the whole spectrum. These appear as two bands very closely adjacent, or, in the manganese oxide spectrum, as one band with the centre reversed, the less refrangible edge of the band being very strong and sharp, the more refrangible being degraded and diffuse. The measurement in brackets indicates the apparent reversal, but is probably the point of separation of two lines	24773	4036·5	4034·9, Mn, Ångström; also Cornu.
	(24800	4032)	(4032·9) Mn, (4031·8) Mn, Angström.
	24817	4029·5	4029·4, Mn, Angström.
			In some photographs there are four lines discernible here. In the spectrum from MnO_2, 4036·5 widens out to 4037.
Uncertain measurement	25683	3894	3894·7, Fe, C. 3895·75, Fe, K. and R.
Line	25815	3874	
,,	25905	3860	3859·3, Fe, C. 3860·03, Fe, K. and R.
,,	25992	3847	
,,	26077	3835	3834, Fe, C. 3834·37, Fe, K. and R.
,,	26132	3827	
,,	26150	3824	3824·1, Fe, C. 3824·58, Fe, K. and R.
,,	26262	3808	3806·4, Cornu. 3805, Fe, C.
,, doubtful	26296	3803	
,, weak, doubtful	..	3764	
,, feeble	27615	3621	3620·6, Fe, C.
,, doubtful	27685	3612	

MANGANESE—(continued).

Description of Spectrum.	$\frac{1}{\lambda}$.	λ.	References.
Line, doubtful	27720	3607·5	3608·3, Fe, C. 3608·99, Fe, K. and R.
,, ,,	27745	3604	3604·6, Fe, C.
Fairly strong line	27800	3600	
Line	27860	3589	
,,	27878	3587	
,, weak	27945	3578	
,,	27962	3576	
,,	28008	3571	
,,	28028	3568	3568·9, Fe, C.
,,	28045	3566	3565·5, Fe, K. and R.
,, doubtful	28075	3562	
,,	28175	3549	
,,	28225	3543	
,,	28282	3536	
,,	28296	3534	
,,	28307	3533	
,,	28325	3530·5	
,,	28330	3529·5	
,,	28350	3528	
,,	28366	3525	
,,	28375	3524	
,,	28445	3515·5	
,,	28455	3514·5	
,,	28462	3513	
,,	28483	3511	
,,	28512	3507	
,,	28545	3503	3501·8, Fe, C.
,,	28585	3498	
,,	28595	3497	3496·8, Fe, C.
,,	28625	3493·5	
,,	28693	3485	
,,	28770	3476	3476·1, Fe, C. 3476·75, Fe, K. and R.
,,	28790	3473·5	
,,	28800	3472	
,,	28814	3470·5	3470·4, Fe, C.
,,	28832	3468	3468, Fe, C.
,,	28842	3467	
,,	28860	3465	3465·5, Fe, C.
,,	28863	3464·5	
,,	28892	3461	3461·5, Fe, C.
,,	28929	3457	3457·8, Fe, C.
,,	28962	3453	3453·2, Fe, C.
,,	29007	3448	
,,	29055	3442	3441·07, Fe, K. and R. Solar line O.
Edge of band	29093	3437	
,, ,,	29118	3434	
Line, nebulous	29148	3431	
,,	29245	3419	
,,	29258	3418	
,,	29280	3415	3415·5, Fe, C.
,,	29298	3413	
,,	29326	3410	
,,	29362	3406	

The Spectrum Obtained by the Intense Ignition of Manganic Oxide.

The pure oxide was prepared from a solution of potassium permanganate by the action of alcohol and a small quantity of sulphurous acid. The precipitate being washed and ignited was heated on a support of kyanite in the flame of the oxy-hydrogen blow-pipe. Exposure one hour and twenty minutes. A similar spectrum is obtained by deflagrating a mixture of finely-powdered potassium permanganate and lamp-black. For comparison iron lines are indicated as follows:—F. and T., Fievez and Thalén; V. and T., Vogel and Thalén; C., Cornu; L. de B., Lecocq de Boisbaudran; K. and R., Kayser and Runge.

Description of Spectrum.	$\frac{1}{\lambda}$.	λ.	References.
Less refrangible edge of band, or a weak nebulous line More refrangible edge of weak band . . .	..	..	
Less refrangible edge of narrow band . .	17028	5873	
More refrangible edge of band	17076	5856	5858, L. de B. 5855·2, Fe, F. and T.
A band appears to commence here	17160	5827	
More refrangible edge of weak band . . .	17240	5800	5807, L. de B. 5800, Fe, F. and T.
„ „ stronger band . .	17385	5752	5759, L. de B.
„ „ „ . .	17490	5717	5719, L. de B.
„ „ „ . .	17603	5681	5683, L. de B.
Edge of band very indistinct	17705	5645	5644, Watts.
„ „ like a line	17787	5622	5623·5, F. and T.
Less refrangible edge of band	17835	5607	5607, Watts.
More „ „ „	17885	5591	5591, Fe, F. and T.
More refrangible edge of last band of this series	17902	5586	5587, L. de B.
Less refrangible edge of weak band . . .	17937	5575	5571·3, Fe, F. and T.
Edge of band, doubtful	..	5474	5473, L. de B. 5473·6, Fe, F. and T.
Nebulous line near edge of band	18370	5443·5	5443·1, Mn, Thalén.
„ „ but sharper	18388	5438	
More refrangible edge of band	18409	5432	5433, Watts. 5432, Huggins.
Less „ „ „	18425	5427	5427, L. de B.
Line on edge of band, strong	18500	5405	5406·6, Thalén.
Edge of band	18518	5400	5398, L. de B. 5399·9, Mn, Thalén.
„ „ and of this series	18627	5368·5	5367, L. de B.
Less refrangible edge of band, very feeble .	18702	5347	5348, Mn, Huggins.
More „ „ „ „ .	18800	5318	5316, Fe, F. and T.
„ „ „ „ weak. Nearly coincident with the Solar line E	18970	5271	5269·5, Fe, F. and T. 5270·43, Fe, K. and R. 5269·65, Fe, K. and R.
More refrangible, stronger edge of band, edges sharp of this and the next two bands. Degraded towards the red	19105	5234	5233·8, Thalén. 5232·1, Fe, F. and T.
The same, stronger	19241	5197	5198·2, Fe, F. and T.
„ weaker	19367	5163	

SPECTRUM obtained by the Intense Ignition of Manganic Oxide—(continued).

Description of Spectrum.	$\frac{1}{\lambda}$.	λ.	References.
More refrangible edge of band, weak . . .	19780	5055	
,, ,, ,, ,, . . .	19927	5018	
,, ,, ,, ,, . . .	20095	4976	
Line on edge of band	20263	4935	
Edge of band, very doubtful	20423	4896	
,, ,, ,, ...	20605	4853	
Line, strong, not very sharp	20710	4828	4831·8, Fe.
,, ,, ,, ...	20875	4790	
Band, very weak	20935	4776·5	
	20965	4770	
Line, fairly strong, not very sharp	20998	4762	4761·3, Mn, THALÉN.
More refrangible edge of band, weak . . .	21055	4749·5	
,, ,, ,, very weak .	21293	4696	
,, ,, ,, ,, .	21476	4656	Bands of manganic oxide.
,, ,, ,, doubtful . .	21740	4600	
,, ,, ,, fairly strong and sharp	21857	4575	
More refrangible edge of band, very weak .	22267	4491	4491, Mn, ÅNGSTRÖM.
			Band peculiar to manganic oxide.
,, ,, ,, stronger .	22436	4457	4457·6, Mn, THALÉN.
,, ,, ,, sharp . .	22713	4403	
,, ,, ,, doubtful .	23293	4293	Band peculiar to manganic oxide.
,, ,, ,, distinct . .	23400	4273	4271·6, Mn, THALÉN.
,, ,, ,, ,, . .	23520	4252	
There are some imperfect edges of band at intervals extending to	23664	4226	4227, Mn, ÅNGSTRÖM.
	24180	4135	Band peculiar to manganic oxide.
Three very doubtful lines, or edges of bands	24196	4133	
	24215	4130	4132·15, Fe, K. and R.
More refrangible edge of band	24238	4125·5	
Line, nebulous, fairly strong, or edge of band	24264	4121	
,, ,, but strong ,, ,,	24514	4079	4079·6, Mn, ANGSTRÖM.
Nebulous line, weak	24538	4075	
,, ,, very weak	24600	4065	
,, ,, ,, ...	24617	4062	4062·9, Fe, C. 4063, Fe, V. and T.
Line, possibly a pair, fairly strong	24664	4054·5	4054·3, Mn, THALÉN.
,, or edge of narrow fluting, sharp . .	24699	4049	4048·7, Mn, C. 4048, Mn, ÅNGSTRÖM.
,, ,, ,, ,, . .	24750	4040	4040·6, Mn, C. Also ÅNGSTRÖM.
The above are both degraded slightly towards the more refrangible edge.			
Very strong band degraded towards the more refrangible edge. The band is more diffuse, stronger, and broader, at the lower part of the flame,	24770	4037	Band of manganic oxide.*
	24845	4025	
Line, possibly a close pair, strong	25036	3994	
,, ,, ,, ,, ...	25055	3991	3991·7, Mn, LOCKYER.

* This band appears as two groups of lines, in ordinary steel and spiegel-eisen, when photographed with short exposure. The less refrangible group consists of three lines, the more refrangible of two lines. They are very sharp and distinct. The two groups become merged into two broad lines in metallic manganese.

SPECTRUM obtained by the Intense Ignition of Manganic Oxide—(continued).

Description of Spectrum.	$\frac{1}{\lambda}$.	λ.	References.
Line, weak	25077	3988	3988, Mn, ÅNGSTRÖM.
„ fairly strong	25682	3894	3894·7, Fe, C.
			3895·75, Fe, K. and R.
„ doubtful, very weak	25735	3886	3886·38, Fe, K. and R.
„ „ „	25760	3882	
„ „ „	25785	3878	Fe, 3878·5.
„ strong	25817	3873	
„ doubtful, very weak	25844	3869	
„ „ „	25865	3866	
„ or edge of band, weak	25907	3860	3859·3, Fe, C.
			3860 3, Fe, K. and R.
„ weak	26000	3846	
„ „	26030	3842	3841·19, Fe, K. and R.
„ stronger	26085	3833·5	3834, Fe, C.
			3834·37, Fe, K. and R.
„ still stronger	26151	3824	3824·1, Fe, C.
			3824·58, Fe, K. and R.
„ doubtful, very weak	26250	3809	
„	26270	3806·5	3806·4, CORNU.
Band weak, and with edges not well defined	26652	3752	
„ „ and very doubtful	26824	3728	3727·78, Fe, K. and R.
Line, or edge of band, very weak	26875	3721	Band of manganic oxide.
„ very weak	26915	3715	
Very feeble band, edge	27250	3670	
Edge of band, very weak, doubtful	27314	3661	„ „ „
„ „ „	27604	3623	„ „ „
Line, hazy, weak	27615	3621	3620·6, Fe, C.
„ „	27685	3612	
„ „	27708	3609	3608·3, Fe, C.
			3608·99, Fe, K. and R.
„ sharp, weak	27753	3603	3604·6, Fe, C.
„ „	27808	3600	
„ very weak	27870	3588	
„ „	27880	3587	
„ sharp, weak	27948	3578	
„ „ stronger	27965	3576	
„ „ fairly strong	28013	3570	3568·9, Fe, C.
			3570·23, Fe, K. and R.
More refrangible edge of band, very weak	28057	3564	3564·1, Fe, C.
			3565·5, Fe, K. and R.
Band, very weak	28080	3561·5	
	28094	3559·5	
Line, or more refrangible edge of band, very weak	28143	3553	
Line, sharp, fairly strong	28183	3548	
Two nebulous lines, very weak	28236	3541·5	
	28254	3539	
Line, very weak, sharp	28305	3533	
„ stronger, sharp	28313	3532	
„ still stronger, sharp	28330	3530	
„ very weak, sharp	28339	3528·5	
„ strong, sharp	28358	3526	3526·5, Fe, K. and R.
„ weak, „	28374	3524	
„ very weak, sharp	28383	3523	
Lines, equally weak and sharp	28400	3521	
	28408	3520	

SPECTRUM obtained by the Intense Ignition of Manganic Oxide—(continued).

Description of Spectrum.	$\frac{1}{\lambda}$.	λ.	References.
Line, very weak	28425	3518	
„ fairly strong	28460	3513·5	
„ weak	28467	3513	
„ double, centre weak	28487	3510	
„ stong, sharp	28520	3506	
„ very strong, sharp	28552	3502	3501·8, Fe, C.
The lines which follow are very weak and not in very sharp focus; the measurements, therefore, are less accurate.			
	28590	3498	
	28600	3496·5	3496·8, Fe, C.
	28622	3494	
	28632	3492·5	
	28650	3490·5	3490·65, Fe, K. and R.
	28665	3488·5	
	28678	3487	
	28694	3485	
	28703	3484	
	28715	3482·5	
	28730	3481	
	28749	3478·5	
	28762	3477	3476·1, Fe, C. 3476·75, Fe, K. and R.
Fairly strong, a pair	28774 28787	3475 3474	3475·52, Fe, K. and R.
Weak, but sharp	28807	3471	
„ „ „	28820	3470	3470·4, Fe, C.
Strong	28838	3468	3468, Fe, C.
Very weak	28849	3466	
Weak	28860	3465	3465·5, Fe, C.
„	28872	3463·5	
Very weak	28883	3462	3461·5, Fe, C.
Weak.	28897	3460·5	
Very strong	28935	3456	3457·8, Fe, C.
Very weak	28978	3451	3453·3, Fe, C.
„ „	28994	3449	
Sharp, less refrangible edge	29013	3447	
Weak band, less refrangible the stronger edge	29028	3445	
Weak, sharp line	29038	3444	
„ „ „	29059	3441	3441·07, Fe, K. and R. Coincident with Solar line O.
„ „ „	29078	3439	
Nebulous group of lines, very close together	29096	3437	
Edge of group	29125	3433·5	
More refrangible edge of group	29156	3430	
Very weak line	29260	3417·5	
Coincides with a solar line	29285	3415	3415·5, Fe, C.
Very strong line	29302	3413	
Very weak line	29323	3410	
„ „ „	29332	3409	
Very strong line	29368	3405	
	29410	3400	
	29454	3395	
	29492	3391	
	29516	3388	

Manganic Oxide.

The following measurements appear to belong to bands peculiar to the manganic oxide spectrum; that it to say, on comparing the photographs of the spectra of metallic manganese and manganic oxide, they appear to consist of the same groups of lines and bands with the addition of these which at once strike the eye when the whole spectrum is viewed. Hence we may conclude that the spectrum obtained by intense ignition of manganic oxide consists of the bands and lines due to the element manganese, with the addition of those bands which are due to the oxide of manganese.

Ivory scale measurements.	Description of Spectrum.	$\frac{1}{\lambda}$.	λ	
66·5	Band	21155	4727	
70·3	. . . . .	21430	4667	
70·3	Band	21430	4667	
75·5	. . . . .	21855	4575	
75·5	. . . . .	21855	4575	
82·0	Band	22360	4472	Band with well-defined edges.
82·7	Band, weak and not well defined	22415	4461	
86·3	. . . . .	22694	4406	
86·3	Band	22694	4406	
97·5	. . . . .	23490	4257	
97·5	Band	23490	4257	
109·0	A sharp line on this edge	24274	4120	
	There is a continuous band of rays extending to	..	3424	
148·5	Band, weak, and with edges not	26652	3752	
154·0	well defined	26930	3713	
160	A very feeble narrow band	27250	3670	
161	. . . . .	27304	3662	
119	Narrow band.	24917	4013	
119·5	. . . . .	24950	4008	
161	Band degraded towards the less	27304	3662	
167	refrangible edge	27615	3621	

There are also the following narrow bands, or flutings, to be noted, not observable without a magnifier.

Ivory scale measurements.	Description of Spectrum.	$\frac{1}{\lambda}$.	λ	
115·5	Sharp edge of narrow fluting	24699	4049	
116·3	,, ,, ,, ,, ...	24732	4043	
	Both are degraded towards their more refrangible edges			
151·0	Fine sharp lines, apparently the edges of	26783	3734	
153·3	flutings	26903	3717	

A broad diffuse band, which is to be seen on the Bessemer flame spectrum between M and N of the solar spectrum, belongs apparently to manganic oxide. There is one,

also overlying M, which is not visible, probably on account of the strong group of iron lines at this point. There is also a weak band beyond N, seen as diffused rays in the Bessemer spectrum, but which appears as two groups of very fine lines in the manganic oxide spectrum.

The following is a list of 87 lines and edges of bands which are common to the spectrum of metallic manganese and that obtained from manganese dioxide. The spectrum of the metal received only half-an-hour's exposure, that of the oxide an hour and twenty minutes. The bands of the one may be a little wider than those of the other owing to the longer exposure. The intense ignition of the oxide certainly causes its dissociation. It will be noticed that many lines have been measured as iron lines by FIEVEZ and THALÉN, VOGEL and THALÉN, KAYSER and RUNGE, and by CORNU. Some of these are unquestionably manganese lines, others may closely approximate, or coincide, in wave-length with iron lines. It is quite certain, after careful examination, that the photographs of the manganese spectrum, whether obtained from the metal or the pure oxide, contain no iron lines, since all the principal lines of this element are absent.

LIST of Lines and Bands Common to the Spectra Obtained from the Metal and from the Oxide of Manganese.

Manganese. λ.	Description of Spectrum, with Lines observed in other Spectra.	Manganese dioxide. λ.	Description of Spectrum, with Lines observed in other Spectra.
5855	Fe, 5855·2, FIEVEZ and THALÉN	5856	Fe, 5855·2, FIEVEZ and THALÉN
5800	Fe, 5800 FIEVEZ and THALÉN	5800	Fe, 5800, FIEVEZ and THALÉN
5712	m.r. edge of weak band	5717	m.r. edge of band
5622	Edge of band and apparently a line Fe, 5623·5, FIEVEZ and THALÉN	5622	Edge of band like a line Fe, 5623·5, FIEVEZ and THALÉN
5591	Edge of band, hazy Fe, 5591, FIEVEZ and THALÉN	5591	m.r. edge of band Fe, 5591, FIEVEZ and THALÉN
5571	Line or l.r. edge of band Fe, 5571·3, FIEVEZ and THALÉN	5575	l.r. edge of weak band
5478	Line Fe, 5478	5474	Edge of band, doubtful Fe, 5473·6, FIEVEZ and THALÉN
5445	Line, distinct, rather broad Fe, 5446, FIEVEZ and THALÉN	5443·5	Nebulous line near edge of band Fe, 5446, FIEVEZ and THALÉN
5438	Line, sharper and weaker	5438	Nebulous line, but sharper
5402	Edge of strong band	5405	Line or edge of band, strong
5391	Fe, 5392, FIEVEZ and THALÉN Band	5400	Band
5370·5	Edge strong Fe, 5370·6, FIEVEZ and THALÉN	5368·5	Edge of band and of this series
5347	Edge of band, doubtful	5347	l.r. edge of band } very feeble
5315	" " "	5318	m.r. edge of band } very feeble
	Fe, 5316, FIEVEZ and THALÉN		
5270	m.r. edge of band Fe, 5269·5, FIEVEZ and THALÉN Coincident with E	5271	m.r. edge of band, weak Nearly coincident with E

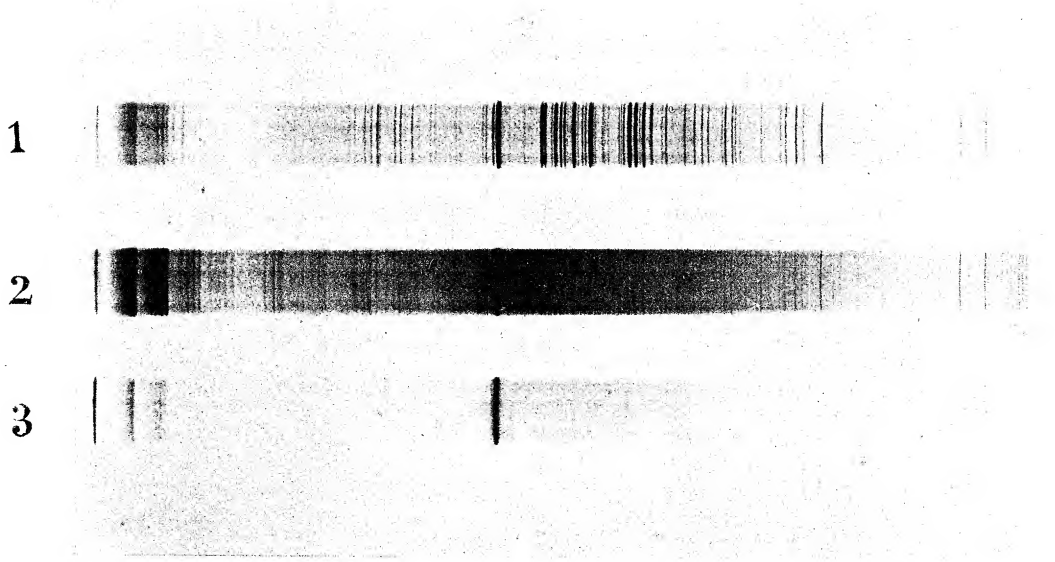
LIST of Lines and Bands Common to the Spectra Obtained from the Metal and from the Oxide of Manganese—(continued).

Manganese. λ.	Description of Spectrum, with Lines observed in other Spectra.	Manganese dioxide. λ.	Description of Spectrum, with Lines observed in other Spectra.
5235	m.r. edge of band	5234	m.r. edge of band
5199	,, ,, ,,	5197	,, ,, ,,
	Fe, 5198·2, FIEVEZ and THALÉN		
5166	m.r. edge of band	5163	,, ,, ,,
	Fe, 5167, FIEVEZ and THALÉN		
4830	Line	4828	Line, strong, not very sharp
	Fe, 4831·8, FIEVEZ and THALÉN		
4791·5	Line	4790	,, ,, ,, ,,
4762	,,	4762	,, fairly strong, not very sharp
4064	,,	4062	Nebulous line, very weak
	Fe, 4063·63, KAYSER and RUNGE;		4062·9, CORNU
	Fe, 4063, VOGEL and THALÉN		4063·63, KAYSER and RUNGE
4056	Line	4054·5	Line, possibly a pair, fairly strong
4049·5	,,	4049	,, or edge of narrow fluting
4041·3	,,	4040	,, ,, ,, ,,
	Fe, 4041·44, KAYSER and RUNGE		4041·44, Fe, KAYSER and RUNGE
	Strongest group of lines in the whole spectrum	4037	Very strong band, degraded towards the red. Band more diffuse, stronger, and broader at the lower part of flame
4036·5*	4035·76 Fe, KAYSER and RUNGE		
4032	4033·16 Fe, ,, ,, ,,		
4029·5	4030·84 Fe, ,, ,, ,,	4025	
3894	Uncertain line	3894	Line, fairly strong
	Fe, 3894·7, CORNU		
	Fe, 3895·75, KAYSER and RUNGE		
3874	Line	3873	,, strong
3860	,,	3860	,, or edge of band, weak
	Fe, 3859·3, CORNU		
	Fe, 3860·03, KAYSER and RUNGE		
3847	Line	3846	,, weak
3835	,,	3833·5	,, stronger
	Fe, 3834, CORNU		
	Fe, 3834·37, KAYSER and RUNGE		
3824	Line	3824	,, still stronger
	Fe, 3824·1, CORNU		
	Fe, 3824·58, KAYSER and RUNGE		
3808	Line	3809	,, doubtful, very weak
3803	,, doubtful	3806·5	,,
	Fe, 3805, CORNU		
3621	Line, feeble	3621	,, hazy, weak
	Fe, 3620·6, 3617·8, CORNU		
3612	Line, doubtful	3612	,, ,, ,,
3607·5	,, ,,	3609	,, ,, ,,
	Fe, 3606·0, CORNU		Fe, 3608·3, CORNU
3604	Line, doubtful	3603	Line, sharp, weak
	Fe, 3604·6, CORNU		
3600	Line, fairly strong	3600	,, ,, ,,
3589	,, very weak	3588	,, very weak
3587	,,	3587	,, ,, ,,
3578	,, weak	3578	,, sharp, weak
3576	,,	3576	,, ,, stronger

* There are undoubtedly four lines here, but two of them are very close together, so that only at the extreme points can four lines be counted.

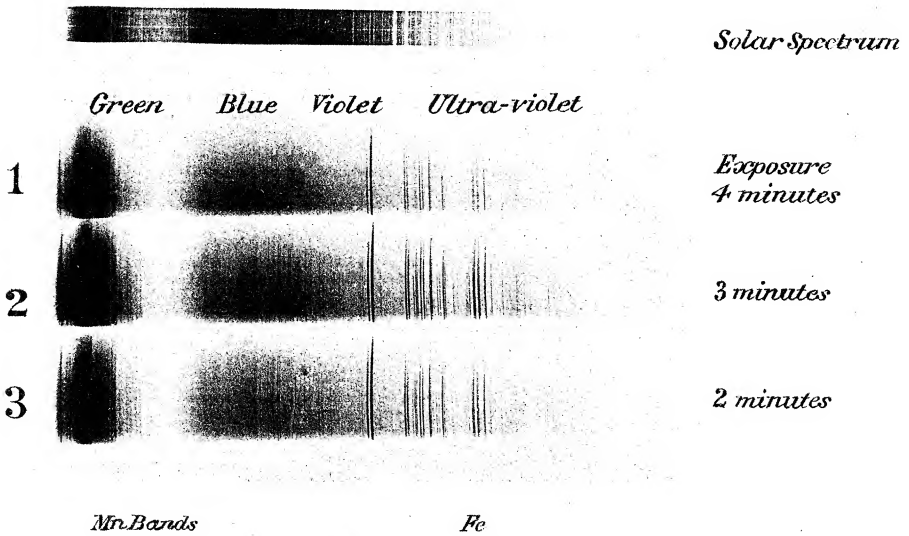
LIST of Lines and Bands Common to the Spectra Obtained from the Metal and from the Oxide of Manganese—(continued).

Manganese. λ.	Description of Spectrum, with Lines observed in other Spectra.	Manganese dioxide. λ.	Description of Spectrum, with Lines observed in other Spectra.
3571	Line Fe, 3568·9, CORNU Fe, 3570·23, KAYSER and RUNGE	3570	Line, sharp, fairly strong
3566	Line Fe, 3564·1, CORNU Fe, 3565·5, KAYSER and RUNGE	3564	m.r. edge of band, very weak
3562	Line, doubtful	3561·5 3559·5	Band, very weak
3549	,,	3548	Line, sharp, fairly strong
3543	,,	3541·5	Nebulous line, very weak
3536	,,	3539	,, ,, ,,
3534	,,	3533	Line, very weak, sharp
3533	,,	3532	,, stronger, sharp
3530·5	,,	3530	,, still stronger, sharp
3529·5	,,	3528·5	,, very weak, sharp
3528	,,		
3525	,, Fe, 3526·51, KAYSER and RUNGE	3526	,, strong, sharp
3524	Line	3524	,, weak, sharp
3513	,,	3513	,, ,,
3511	,,	3510	,, double, centre weak
3507	,,	3506	,, strong, sharp
3503	,, Fe, 3501·8, CORNU (reversed)	3502	,, very strong, sharp
3498	Line Fe, 3496·8, CORNU Fe, 3497·92, Fe, K. and R.	3498	
3497	Line	3496·5	
3493·5	,,	3494	
3485	,,	3485	
3476	,, Fe, 3476·1, CORNU (reversed)	3475	
3473·5	Line	3474	
3472	,,	3471	Lines very weak and not in very
3470·5	,,	3470	sharp focus or hazy lines
3468	Fe, 3468, CORNU (reversed)	3468	
3467		3466	
3465	Fe, 3465·5, CORNU	3465	
3464·5		3463·5	
3461	Fe, 3461·5, ,,	3462	
3457	Fe, 3457·8, ,,	3456	
3453	Fe, 3453·3, ,,	3451	
3448		3449	
3442		3441	Solar line O 3441·07, Fe, KAYSER and RUNGE
3437	Edge of band	3437	Nebulous group of lines very close
3434	,, ,,	3433·5	together
3431	Line, nebulous	3430	m.r. edge of group
3419	,, ,,	3417·5	Very weak line
3418	,, ,,		
3415	,, Fe. 3415·5, CORNU	3415	Line coincides with with a solar line
3413	Line	3413	Very strong line
3410	,,	3410	,, weak line



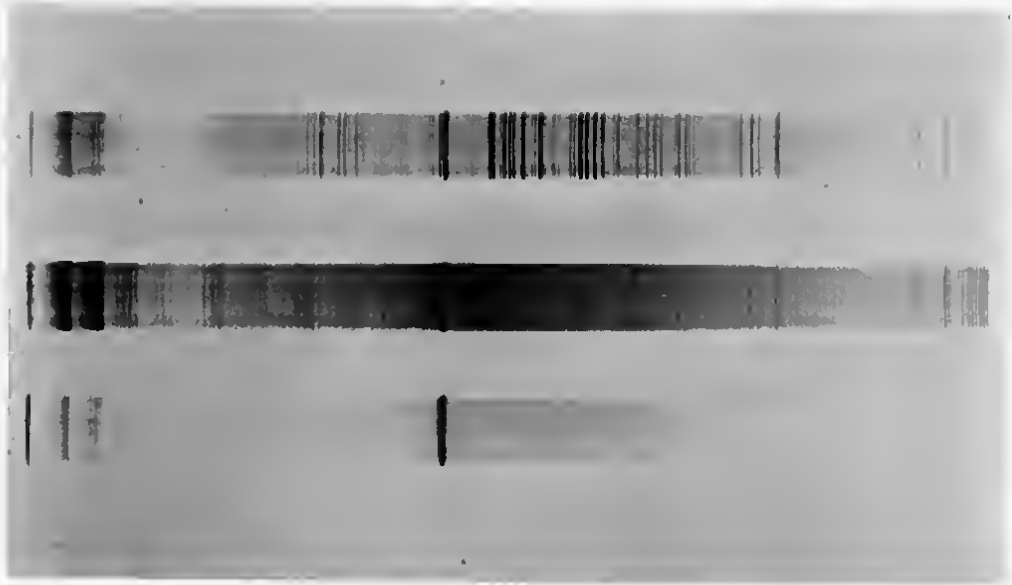
Manganese Spectra,

1, *Spiegeleisen*, 2, *Ferromanganese*, 3, *Manganic Oxide*.



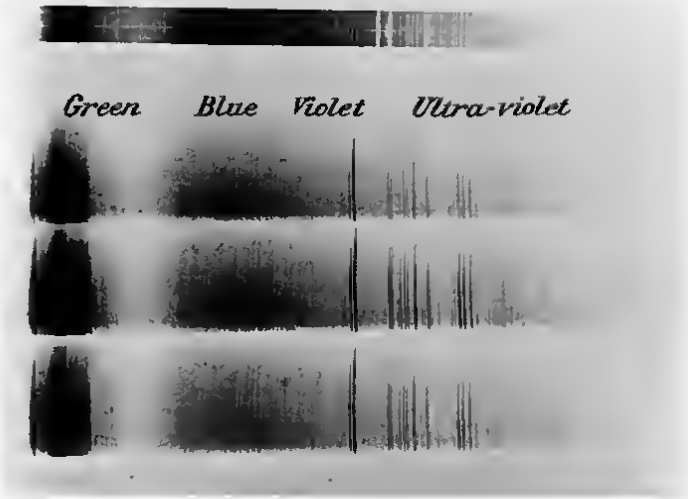
Bessemer Flame Spectra

Plate 8. Crewe



Manganese Spectra,

1, *Spiegeleisen*, 2, *Ferromanganese*, 3, *Manganic Oxide*.



Bessemer Flame Spectra

Plate 8 Crewe